

WHAT IS CLAIMED IS:

1 1. A plasma display panel device comprising:

2 a panel unit having a pair of a first and a second
3 electrode, and a third electrode that intersects the
4 electrode pair to define a discharge cell; and

5 a drive unit that drives the panel unit using a drive
6 method having a write period and a sustain period, by applying,
7 in the sustain period, a voltage to the third electrode and
8 a voltage to the electrode pair, so as to generate a sustain
9 discharge between the first and second electrodes in the
10 sustain period, wherein

11 the drive unit changes a potential of the third
12 electrode during the sustain discharge.

1 2. The plasma display panel device of claim 1, wherein

2 the change in the potential of the third electrode
3 during the sustain discharge is a decrease from a potential
4 V_1 to a potential V_2 .

1 3. The plasma display panel device of claim 2, wherein

2 the drive unit increases the potential of the third
3 electrode from a potential V_0 to the potential V_1 in the
4 sustain period.

1 4. The plasma display panel device of claim 3, wherein
2 the potentials V0 and V2 are equal.

1 5. The plasma display panel device of claim 3, wherein
2 the potentials V0 and V2 are set in a range that will
3 not cause a discharge to occur between the third electrode
4 and the first or second electrode.

1 6. The plasma display panel device of claim 1, wherein
2 a waveform of the voltage applied to the third electrode
3 in the sustain period is a pulse waveform, and
4 the change in the potential of the third electrode
5 during the sustain discharge corresponds to a fall in the
6 pulse waveform.

1 7. The plasma display panel device of claim 1, wherein
2 the change in the potential of the third electrode
3 occurs in a period equal to 80 % of a time constant of the
4 sustain discharge.

1 8. The plasma display panel device of claim 1, wherein
2 the electrode pair is provided on a first substrate,
3 and
4 the third electrode is provided on a second substrate

5 that is disposed facing the first substrate across a
6 discharge space.

1 9. The plasma display panel device of claim 8, wherein
2 one of the electrodes in the pair is a scan electrode
3 and the other electrode in the pair is a sustain electrode,
4 and
5 the third electrode is a data electrode.

1 10. The plasma display panel device of claim 1, wherein
2 a waveform of the voltage applied to the electrode pair
3 in the sustain period has a slope requiring a duration T to
4 at least one of rise and fall.

1 11. The plasma display panel device of claim 10, wherein
2 T is in a range having a width of $\pm 20\%$ with respect
3 to a reference value in a range of 250 nsec to 800 nsec.

1 12. The plasma display panel device of claim 11, wherein
2 the reference value of T is in a range of 250 nsec to
3 500 nsec.

1 13. The plasma display panel device of claim 10, wherein
2 the voltage waveform applied to the electrode pair in

3 the sustain period is a pulse waveform that alternates
4 repeatedly between high and low potentials, the high periods
5 being of equal duration to the low periods, and

6 the change in the potential of the third electrode
7 occurs in a range of $T - 0.15 \mu\text{sec}$ to $T + 0.25 \mu\text{sec}$ after
8 the voltage waveform applied to at least one of the first
9 and second electrode begins to change.

1 14. The plasma display panel device of claim 13, wherein
2 the change in the potential of the third electrode from
3 V_1 to V_2 occurs in a range of $T - 0.05 \mu\text{sec}$ to $T + 0.15 \mu$
4 sec after the voltage waveform applied to at least one of
5 the first and second electrode begins to change.

1 15. The plasma display panel device of claim 13, wherein
2 the potential of the third electrode decreases from a
3 potential V_1 to a potential V_2 in the range.

1 16. The plasma display panel device of claim 13, wherein
2 the voltage waveform applied to the first electrode is
3 out of phase with the voltage waveform applied to the second
4 electrode by a half cycle.

1 17. The plasma display panel device of claim 10, wherein

2 the voltage waveform applied to the electrode pair in
3 the sustain period is a pulse waveform that alternates
4 repeatedly between high and low potentials, the high periods
5 being longer than the low periods, and

6 the change in the potential of the third electrode
7 occurs in a range of $T - 0.25 \mu\text{sec}$ to $T + 0.25 \mu\text{sec}$ after
8 the voltage waveform applied to at least one of the first
9 and second electrode begins to change.

1 18. The plasma display panel device of claim 17, wherein
2 the change in the potential of the third electrode from
3 V1 to V2 occurs in a range of $T - 0.15 \mu\text{sec}$ to $T + 0.05 \mu$
4 sec after the voltage waveform applied to at least one of
5 the first and second electrode begins to change.

1 19. The plasma display panel device of claim 17, wherein
2 the potential of the third electrode decreases from a
3 potential V1 to a potential V2 in the range.

1 20. The plasma display panel device of claim 17, wherein
2 the voltage waveform applied to the first electrode is
3 out of phase with the voltage waveform applied to the second
4 electrode by a half cycle.

1 21. The plasma display panel device of claim 10, wherein
2 the voltage waveform applied to the electrode pair in
3 the sustain period is a pulse waveform that alternates
4 repeatedly between high and low potentials, the high periods
5 being shorter than the low periods, and
6 the change in the potential of the third electrode
7 occurs in a range of (i) $T - 0.05 \mu\text{sec}$ to $T - 0.35 \mu\text{sec}$ after
8 the voltage waveform applied to at least one of the first
9 and second electrode begins to rise, or (ii) $T - 0.45 \mu\text{sec}$
10 to $T - 0.05 \mu\text{sec}$ after the voltage waveform applied to at
11 least one of the first and second electrode begins to fall.

1 22. The plasma display panel device of claim 21, wherein
2 the change in the potential of the third electrode from
3 V_1 to V_2 occurs in a range of (i) $T + 0.05 \mu\text{sec}$ to $T - 0.25$
4 μsec after the voltage waveform applied to at least one of
5 the first and second electrode begins to rise, or (ii) $T -$
6 $0.35 \mu\text{sec}$ to $T - 0.15 \mu\text{sec}$ after the voltage waveform
7 applied to at least one of the first and second electrode
8 begins to fall.

1 23. The plasma display panel device of claim 21, wherein
2 the potential of the third electrode decreases from a
3 potential V_1 to a potential V_2 in the range.

1 24. The plasma display panel device of claim 21, wherein
2 the voltage waveform applied to the first electrode is
3 out of phase with the voltage waveform applied to the second
4 electrode by a half cycle.

1 25. A plasma display panel device, comprising:
2 a panel unit having a pair of a first and a second
3 electrode, and a third electrode that interscots the
4 electrode pair to define a discharge cell; and
5 a drive unit that drives the panel unit using a drive
6 method having a write period and a sustain period, by applying,
7 in the sustain period, a voltage to the third electrode and
8 a voltage to the electrode pair, so as to generate a sustain
9 discharge between the first and second electrodes in the
10 sustain period, wherein
11 the drive unit changes a potential of the third
12 electrode from V_0 to V_1 prior to the sustain discharge, and
13 from V_1 to V_2 after the sustain discharge, and
14 the potentials V_0 , V_1 and V_2 are set so that $V_1 > V_0$
15 and $V_1 > V_2$, or $V_0 > V_1$ and $V_2 > V_1$.

1 26. The plasma display panel device of claim 25, wherein
2 the drive unit increases the potential of the third
3 electrode from V_0 to V_1 prior to a first sustain discharge,

4 sustains the potential V1, and decreases the potential of
5 the third electrode from V1 to V2 after a second sustain
6 discharge that is subsequent to the first sustain discharge.

1 27. The plasma display panel device of claim 25, wherein
2 the drive unit decreases the potential of the third
3 electrode from V0 to V1 prior to a first sustain discharge,
4 sustains the potential V1, and increases the potential of
5 the third electrode from V1 to V2 after a second sustain
6 discharge that is subsequent to the first sustain discharge.

1 28. The plasma display panel device of claim 25, wherein
2 one of the electrodes in the pair is a scan electrode
3 and the other electrode in the pair is a sustain electrode,
4 and
5 the third electrode is a data electrode.

1 29. The plasma display panel device of claim 25, wherein
2 a cycle of the voltage waveform applied to the third
3 electrode in the sustain period is an integer multiple of
4 a cycle of the voltage waveform applied to the electrode pair.

1 30. The plasma display panel device of claim 29, wherein
2 one of the electrodes in the pair is a scan electrode

3 and the other electrode in the pair is a sustain electrode,
4 and
5 the third electrode is a data electrode.

1 31. The plasma display panel device of claim 25, wherein
2 a binding capacity of the first electrode with the third
3 electrode is different from a binding capacity of the second
4 electrode with the third electrode, and
5 the drive unit increases the potential of the third
6 electrode when a potential of the electrode in the pair with
7 the greater binding capacity is high.

1 32. The plasma display panel device of claim 31, wherein
2 one of the electrodes in the pair is a scan electrode
3 and the other electrode in the pair is a sustain electrode,
4 and
5 the third electrode is a data electrode.

1 33. A plasma display panel device, comprising:
2 a panel unit having a pair of a first and a second
3 electrode, and a third electrode that intersects the
4 electrode pair to define a discharge cell; and
5 a drive unit that drives the panel unit using a drive
6 method having a write period and a sustain period, by applying,

7 in the sustain period, a voltage to the third electrode and
8 a voltage to the electrode pair, so as to generate a sustain
9 discharge between the first and second electrodes in the
10 sustain period, wherein

11 the drive unit includes:

12 a detection subunit operable to detect a characteristic
13 of an image for display by the panel unit; and

14 a control subunit operable to perform a control in the
15 sustain period to change a potential of the third electrode
16 according to the detected characteristic.

1 34. The plasma display panel device of claim 33, wherein
2 the detection subunit detects a brightness average of
3 the image as the characteristic.

1 35. The plasma display panel device of claim 34, wherein
2 the detection subunit further detects a temperature of
3 the panel unit as the characteristic, and
4 the control subunit conducts the control based on the
5 detected brightness average and temperature.

1 36. The plasma display panel device of claim 33, wherein
2 a waveform of the voltage applied to the third electrode
3 in the sustain period is a pulse waveform;

4 The change in the potential of the third electrode
5 during the sustain discharge corresponds to a fall in the
6 pulse waveform.

1 37. The plasma display panel device of claim 33, wherein
2 the voltage waveform applied to the third electrode in
3 the sustain period is in synchronization with the voltage
4 waveform applied to the electrode pair.

1 38. The plasma display panel device of claim 33, wherein
2 the control by the control subunit is conducted at a
3 fall time of the voltage waveform applied to the third
4 electrode in the sustain period.

1 39. A plasma display panel device, comprising:
2 a panel unit having a pair of a first and a second
3 electrode, and a third electrode that intersects the
4 electrode pair to define a discharge cell; and
5 a drive unit that drives the panel unit using a drive
6 method having a write period and a sustain period, by applying,
7 in the sustain period, a voltage to the third electrode and
8 a voltage to the electrode pair, so as to generate a sustain
9 discharge between the first and second electrodes in the
10 sustain period, wherein

11 in the sustain period, the drive unit performs a control
12 in which a potential of the third electrode is changed during
13 the sustain discharge, so as to hasten the generation of the
14 sustain discharge in comparison to when the potential is not
15 changed.

1 4G. A plasma display panel device, comprising:

2 a panel unit having first and second substrates that
3 face each other across a discharge space, a pair of a first
4 and a second electrode being provided on the first substrate,
5 and a phosphor layer and a third electrode that intersects
6 the electrode pair to define a discharge cell being provided
7 on the second substrate,

8 a drive unit that drives the panel unit using a drive
9 method having a write period and a sustain period, by applying,
10 in the sustain period, a voltage to the third electrode and
11 a voltage to the electrode pair, so as to generate a sustain
12 discharge between the first and second electrodes in the
13 sustain period, wherein

14 in the sustain period, the drive unit performs a control
15 in which a potential of the third electrode is changed during
16 the sustain discharge, so as to shift a region in which the
17 sustain discharge is generated closer to the phosphor layer
18 in comparison to when the potential is not changed.

1 41. A plasma display panel device, comprising:
2 a panel unit having a pair of a first and a second
3 electrode, and a third electrode that intersects the
4 electrode pair to define a discharge cell; and
5 a drive unit that drives the panel unit using a drive
6 method having a write period and a sustain period, by applying,
7 in the sustain period, a voltage to the third electrode and
8 a voltage to the electrode pair, so as to generate a sustain
9 discharge between the first and second electrodes in the
10 sustain period, wherein
11 in the sustain period, the drive unit performs a control
12 in which a potential of the third electrode is changed during
13 the sustain discharge, so as to shift a discharge path of
14 the sustain discharge closer to the third electrode in
15 comparison to when the potential is not changed.

1 42. A plasma display panel device, comprising:
2 a panel unit having a pair of a first and a second
3 electrode, and a third electrode that intersects the
4 electrode pair to define a discharge cell; and
5 a drive unit that drives the panel unit using a drive
6 method having a write period and a sustain period, by applying,
7 in the sustain period, a voltage to the third electrode and
8 a voltage to the electrode pair, so as to generate a sustain

9 discharge between the first and second electrodes in the
10 sustain period, wherein

11 in the sustain period, the drive unit performs a control
12 in which a potential of the third electrode is changed during
13 the sustain discharge, so as to lengthen a discharge path
14 of the sustain discharge in comparison to when the potential
15 is not changed.

1 43. A drive method for a plasma display panel device that
2 includes (i) a panel unit having a pair of a first and a second
3 electrode and a third electrode that intersects the electrode
4 pair to define a discharge cell, and (ii) a drive unit that
5 drives the panel unit using the drive method, which has a
6 write step and a sustain step, by applying, in the sustain
7 step, a voltage to the third electrode and a voltage to the
8 electrode pair, so as to generate a sustain discharge between
9 the first and second electrodes, wherein
10 in the sustain step, the drive unit changes a potential
11 of the third electrode during the sustain discharge.

1 44. The drive method of claim 43, wherein

2 the change in the potential of the third electrode
3 during the sustain discharge is a decrease from a potential
4 V1 to a potential V2.

1 45. The drive method of claim 44, wherein
2 in the sustain step, the drive unit increases the
3 potential of the third electrode from a potential V0 to the
4 potential V1.

1 46. The drive method of claim 45, wherein
2 the potentials V0 and V2 are equal.

1 47. The drive method of claim 45, wherein
2 the potentials V0 and V2 are set in a range that will
3 not cause a discharge to occur between the third electrode
4 and the first or second electrode.

1 48. The drive method of claim 43, wherein
2 a waveform of the voltage applied to the third electrode
3 in the sustain step is a pulse waveform, and
4 the change in the potential of the third electrode
5 during the sustain discharge corresponds to a fall in the
6 pulse waveform.

1 49. The drive method of claim 43, wherein
2 the change in the potential of the third electrode
3 occurs in a period equal to 80 % of a time constant of the
4 sustain discharge.

1 50. The drive method of claim 43, wherein
2 a waveform of the voltage applied to the electrode pair
3 in the sustain step has a slope requiring a duration T to
4 at least one of rise and fall.

1 51. The drive method of claim 50, wherein
2 T is in a range having a width of $\pm 20\%$ with respect
3 to a reference value in a range of 250 nsec to 800 nsec.

1 52. The drive method of claim 51, wherein
2 the reference value of T is in a range of 250 nsec to
3 500 nsec.

1 53. The drive method of claim 50, wherein
2 the voltage waveform applied to the electrode pair in
3 the sustain step is a pulse waveform that alternates
4 repeatedly between high and low potentials, the high periods
5 being of equal duration to the low periods, and
6 the change in the potential of the third electrode
7 occurs in a range of $T - 0.15 \mu\text{sec}$ to $T + 0.25 \mu\text{sec}$ after
8 the voltage waveform applied to at least one of the first
9 and second electrode begins to change.

1 54. The drive method of claim 53, wherein

2 the change in the potential of the third electrode from
3 V1 to V2 occurs in a range of $T - 0.05 \mu\text{sec}$ to $T + 0.15 \mu$
4 sec after the voltage waveform applied to at least one of
5 the first and second electrode begins to change.

1 55. The drive method of claim 53, wherein
2 the potential of the third electrode decreases from a
3 potential V1 to a potential V2 in the range.

1 56. The drive method of claim 53, wherein
2 the voltage waveform applied to the first electrode is
3 out of phase with the voltage waveform applied to the second
4 electrode by a half cycle.

1 57. The drive method of claim 50, wherein
2 the voltage waveform applied to the electrode pair in
3 the sustain step is a pulse waveform that alternates
4 repeatedly between high and low potentials, the high periods
5 being longer than the low periods, and
6 the change in the potential of the third electrode
7 occurs in a range of $T - 0.25 \mu\text{sec}$ to $T + 0.25 \mu\text{sec}$ after
8 the voltage waveform applied to at least one of the first
9 and second electrode begins to change.

1 58. The drive method of claim 57, wherein
2 the change in the potential of the third electrode from
3 V1 to V2 occurs in a range of $T - 0.15 \mu\text{sec}$ to $T + 0.05 \mu$
4 sec after the voltage waveform applied to at least one of
5 the first and second electrode begins to change.

1 59. The drive method of claim 57, wherein
2 the potential of the third electrode decreases from a
3 potential V1 to a potential V2 in the range.

1 60. The drive method of claim 57, wherein
2 the voltage waveform applied to the first electrode is
3 out of phase with the voltage waveform applied to the second
4 electrode by a half cycle.

1 61. The drive method of claim 50, wherein
2 the voltage waveform applied to the electrode pair in
3 the sustain step is a pulse waveform that alternates
4 repeatedly between high and low potentials, the high periods
5 being shorter than the low periods, and
6 the change in the potential of the third electrode
7 occurs in a range of (i) $T - 0.05 \mu\text{sec}$ to $T + 0.35 \mu\text{sec}$ after
8 the voltage waveform applied to at least one of the first
9 and second electrode begins to rise, or (ii) $T - 0.45 \mu\text{sec}$

10 to $T - 0.05 \mu\text{sec}$ after the voltage waveform applied to at
11 least one of the first and second electrode begins to fall.

1 62. The drive method of claim 61, wherein
2 the change in the potential of the third electrode from
3 V_1 to V_2 occurs in a range of (i) $T + 0.05 \mu\text{sec}$ to $T + 0.25$
4 μsec after the voltage waveform applied to at least one of
5 the first and second electrode begins to rise, or (ii) $T -$
6 $0.35 \mu\text{sec}$ to $T - 0.15 \mu\text{sec}$ after the voltage waveform
7 applied to at least one of the first and second electrode
8 begins to fall.

1 63. The drive method of claim 61, wherein
2 the potential of the third electrode decreases from a
3 potential V_1 to a potential V_2 in the range.

1 64. The drive method of claim 61, wherein
2 the voltage waveform applied to the first electrode is
3 out of phase with the voltage waveform applied to the second
4 electrode by a half cycle.

1 65. A drive method for a plasma display panel device that
2 includes (1) a panel unit having a pair of a first and a second
3 electrode and a third electrode that intersects the electrode

4 pair to define a discharge cell, and (ii) a drive unit that
5 drives the panel unit using the drive method, which has a
6 write step and a sustain step, by applying, in the sustain
7 step, a voltage to the third electrode and a voltage to the
8 electrode pair, so as to generate a sustain discharge between
9 the first and second electrodes, wherein

10 in the sustain step, the drive unit changes a potential
11 of the third electrode from V_0 to V_1 prior to the sustain
12 discharge, and from V_1 to V_2 after the sustain discharge,
13 and

14 the potentials V_0 , V_1 and V_2 are set so that $V_1 > V_0$
15 and $V_1 > V_2$, or $V_0 > V_1$ and $V_2 > V_1$.

1 66. The drive method of claim 65, wherein

2 in the sustain step, the drive unit increases the
3 potential of the third electrode from V_0 to V_1 prior to a
4 first sustain discharge, sustains the potential V_1 , and
5 decreases the potential of the third electrode from V_1 to
6 V_2 after a second sustain discharge that is subsequent to
7 the first sustain discharge.

1 67. The drive method of claim 66, wherein

2 in the sustain step, the drive unit decreases the
3 potential of the third electrode from V_0 to V_1 prior to a

4 first sustain discharge, sustains the potential V1, and
5 increases the potential of the third electrode from V1 to
6 V2 after a second sustain discharge that is subsequent to
7 the first sustain discharge.

1 68. The drive method of claim 65, wherein
2 a cycle of the voltage waveform applied to the third
3 electrode in the sustain step is an integer multiple of a
4 cycle of the voltage waveform applied to the electrode pair.

1 69. The drive method of claim 65, wherein
2 a binding capacity of the first electrode with the third
3 electrode is different from a binding capacity of the second
4 electrode with the third electrode, and
5 the drive unit increases the potential of the third
6 electrode when a potential of the electrode in the pair with
7 the greater binding capacity is high.

1 70. A drive method for a plasma display panel device that
2 includes (i) a panel unit having a pair of a first and a second
3 electrode and a third electrode that intersects the electrode
4 pair to define a discharge cell, and (ii) a drive unit that
5 drives the panel unit using the drive method, which has a
6 write step and a sustain step, by applying, in the sustain

7 step, a voltage to the third electrode and a voltage to the
8 electrode pair, so as to generate a sustain discharge between
9 the first and second electrodes, wherein
10 the drive unit detects a characteristic of an image for
11 display by the panel unit, and performs a control in the
12 sustain step to change a potential of the third electrode
13 according to the detected characteristic.

1 71. The drive method of claim 70, wherein
2 the drive unit detects a brightness average of the image
3 as the characteristic.

1 72. The drive method of claim 71, wherein
2 the drive unit further detects a temperature of the
3 panel unit as the characteristic, and conducts the control
4 based on the detected brightness average and temperature.

1 73. The drive method of claim 70, wherein
2 a waveform of the voltage applied to the third electrode
3 in the sustain step is a pulse waveform;
4 the change in the potential of the third electrode
5 during the sustain discharge corresponds to a fall in the
6 pulse waveform.

1 74. The drive method of claim 70, wherein
2 the voltage waveform applied to the third electrode in
3 the sustain step is in synchronization with the voltage
4 waveform applied to the electrode pair.

1 75. The drive method of claim 70, wherein
2 in the sustain step, the control by the drive unit is
3 conducted at a fall time of the voltage waveform applied to
4 the third electrode.

1 76. A drive method for a plasma display panel device that
2 includes (i) a panel unit having a pair of a first and a second
3 electrode and a third electrode that intersects the electrode
4 pair to define a discharge cell, and (ii) a drive unit that
5 drives the panel unit using the drive method, which has a
6 write step and a sustain step, by applying, in the sustain
7 step, a voltage to the third electrode and a voltage to the
8 electrode pair, so as to generate a sustain discharge between
9 the first and second electrodes, wherein
10 in the sustain step, the drive unit performs a control
11 in which a potential of the third electrode is changed during
12 the sustain discharge, so as to hasten the generation of the
13 sustain discharge in comparison to when the potential is not
14 changed.

1 77. A drive method for a plasma display panel device that
2 includes (i) a panel unit having a pair of a first and a second
3 electrode, a third electrode that intersects the electrode
4 pair to define a discharge cell, and a phosphor layer disposed
5 over the third electrode, and (ii) a drive unit that drives
6 the panel unit using the drive method, which has a write step
7 and a sustain step, by applying, in the sustain step, a voltage
8 to the third electrode and a voltage to the electrode pair,
9 so as to generate a sustain discharge between the first and
10 second electrodes, wherein

11 in the sustain step, the drive unit performs a control
12 in which a potential of the third electrode is changed during
13 the sustain discharge, so as to shift a region in which the
14 sustain discharge is generated closer to the phosphor layer
15 in comparison to when the potential is not changed.

1 78. A drive method for a plasma display panel device that
2 includes (i) a panel unit having a pair of a first and a second
3 electrode and a third electrode that intersects the electrode
4 pair to define a discharge cell, and (ii) a drive unit that
5 drives the panel unit using the drive method, which has a
6 write step and a sustain step, by applying, in the sustain
7 step, a voltage to the third electrode and a voltage to the
8 electrode pair, so as to generate a sustain discharge between

9 the first and second electrodes, wherein
10 in the sustain step, the drive unit performs a control
11 in which a potential of the third electrode is changed during
12 the sustain discharge, so as to shift a discharge path of
13 the sustain discharge closer to the third electrode in
14 comparison to when the potential is not changed.

1 79. A drive method for a plasma display panel device that
2 includes (i) a panel unit having a pair of a first and a second
3 electrode and a third electrode that intersects the electrode
4 pair to define a discharge cell, and (ii) a drive unit that
5 drives the panel unit using the drive method, which has a
6 write step and a sustain step, by applying, in the sustain
7 step, a voltage to the third electrode and a voltage to the
8 electrode pair, so as to generate a sustain discharge between
9 the first and second electrodes, wherein
10 in the sustain step, the drive unit performs a control
11 in which a potential of the third electrode is changed during
12 the sustain discharge, so as to lengthen a discharge path
13 of the sustain discharge in comparison to when the potential
14 is not changed.